Cave- and Crevice-Dwelling Bats on USACE Projects: Townsend's Big-eared Bat (*Corynorhinus townsendii*)

by Wilma A. Mitchell

PURPOSE: This document is one in a series of U.S. Army Engineer Research and Development Center (ERDC) technical notes produced under the Ecosystem Management and Restoration Research Program (EMRRP). The technical notes identify sensitive species potentially impacted by U.S. Army Corps of Engineers (Corps) reservoir operations and are products of the EMRRP work unit entitled "Reservoir Operations – Impacts on Habitats of Target Species" (Dickerson, Martin, and Allen 1999; Kasul, Martin, and Allen 2000). This technical note provides information on selected bat species that have the potential to occur on Corps projects in the eastern United States and be impacted by Corps activities. It is linked to another technical note (ERDC TN-EMRRP-SI-24) that presents an overview of general habitat requirements, impacts, and management needs for these species. Although Townsend's big-eared bat (*Corynorhinus townsendii*) consists of five subspecies, this document focuses on the Ozark (*C. t. ingens*) (Figure 1) and Virginia (*C. t. virginianus*) big-eared bats because of their federally endangered status. The ecology, legal status, potential impacts, and management guidelines are described primarily for these eastern subspecies.

Figure 1. Ozark big-eared bat (*Corynorhinus townsendii ingens*) (photo courtesy of U.S. Fish & Wildlife Service)

DISTRIBUTION: The Townsend's big-eared bat occurs from British Columbia, Canada, south through the western United States to Mexico and in two disjunct areas of the eastern United States (Harvey, Altenbach, and Best 1999) (Figure 2). The Ozark big-eared bat is historically known from the Ozark Mountains of eastern Oklahoma, northwestern Arkansas, and southern Missouri; however, it may now be extirpated from Missouri (U.S. Fish and Wildlife Service (USFWS), 8 Dec 2000). The Virginia big-eared bat is known from only a few counties in Virginia, West Virginia, North Carolina, and Kentucky. Two subspecies of Townsend's big-eared bat occur in the western United States: (1) Townsend's (*C. t. townsendii*) from southern British Columbia along the west coast to southern California; and (2) Western (*C. t. pallescens*) from eastern Colorado and western Texas, Oklahoma, and South Dakota to the eastern slopes of the Cascade Mountain Range, the southwestern United States, and Baja, California (Hall 1981). *C. t. australis* occurs in Mexico.

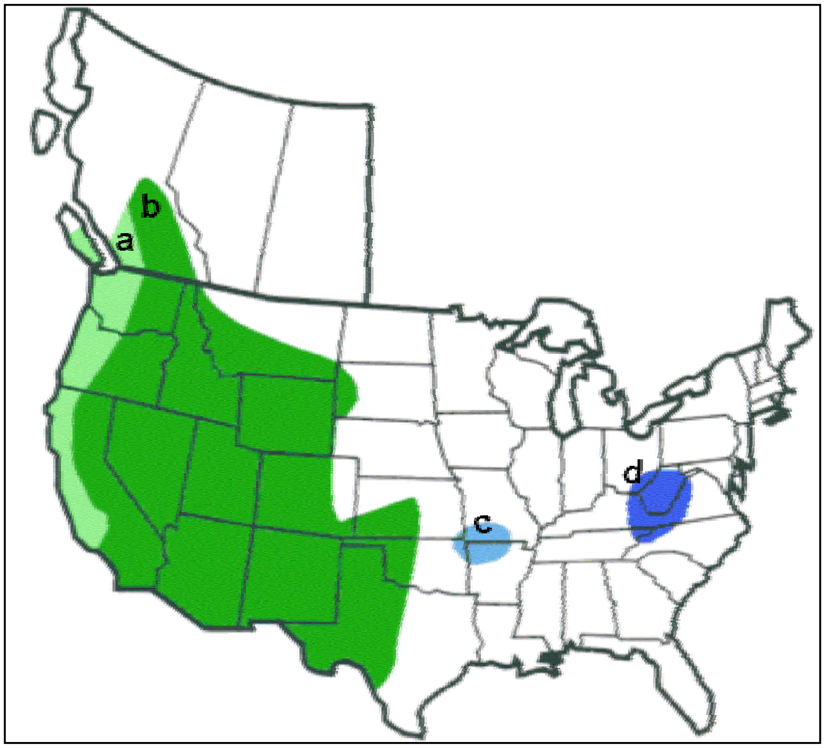

Figure 2. Approximate range of Townsend's big-eared bat subspecies in the United States and Canada (a) Townsend's; (b) Western; (c) Ozark; (d) Virginia (after Harvey, Altenbach, and Best (1999))

STATUS: The Ozark and Virginia big-eared bats were listed by the USFWS as federally endangered in November 1979 (World Wildlife Fund (WWF) 1990a, 1990b). The western subspecies of Townsend's big-eared bat are listed as species of special concern (Harvey, Altenbach, and Best 1999). In the early 1990s the population of Ozark big-eared bats was estimated to be 1800 individuals (USFWS, 8 Dec 2000). The most recent data indicate that about 1700 individuals remain; approximately 1400 of these live in a few caves in eastern Oklahoma, and the remainder inhabit two caves in Arkansas (Arkansas Game and Fish Commission, 12 Dec 2000). The population of Virginia big-eared bats declined sharply from the 1950s to the early 1980s but has since increased slowly (Pupek 1997). The total population of the Virginia big-eared bat was estimated at approximately 13,600 individuals in the early 1990s (USFWS, 8 Dec 2000). The Kentucky population numbered approximately 3700 individuals by the mid-1990s (Adam, Lacki, and Barnes 1994), and populations in some caves of West Virginia increased as much as 350 percent from 1983 to 1995 (Pupek 1997). Surveys of hibernacula during the winter of 1994-1995 found 6378 individuals in Hellhole Cave, West Virginia, which is the largest known concentration of Virginia big-eared bats in the eastern United States (USFWS 1995b). In June 1995 a census of the 11 known summer colonies in West Virginia resulted in a total population estimate of 6338 bats (USFWS 1996), and surveys in June 1996 indicated a stable population in the state (USFWS 1997).

HABITAT: The distribution of Townsend's big-eared bat tends to be geomorphically determined by the availability of caves or cave-like roosting habitats such as old mines (Pierson et al. 1999). In

Idaho, the largest known populations are associated with lava flows in the southwestern part of the state (Genter 1986, Wackenhut 1990), whereas eastern caves are typically located in limestone karst regions dominated by mature hardwood forests of hickory (*Carya* spp.), beech (*Fagus grandifolia*), maple (*Acer* spp.), and hemlock (*Tsuga* spp.) (WWF 1990a, 1990b). Townsend's big-eared bat uses caves and abandoned mines year-round as both winter hibernacula and summer maternity roosts (WWF 1990a, 1990b; Sherwin, Stricklan, and Rogers 2000). The western subspecies frequently roost in man-made structures, such as tunnels, abandoned buildings (Pierson et al. 1999), and under bridges (Adam and Hayes 2000), but this has not been observed in Virginia or Ozark populations. Maternity roosts of the Virginia big-eared bat in Kentucky are occasionally located in rock shelters formed in sandstone cliffs (Lacki, Adam, and Shoemaker 1994).

In Oklahoma, the Ozark big-eared bat uses the same caves in summer and winter (Clark, Clark, and Leslie 1997). Hibernating bats roost in the coldest regions of the coldest caves, and clusters of females in summer maternity caves roost in areas with temperatures cooler than those found near solitary bats (Clark et al. 1996). Temperatures in hibernacula usually range from 2.5 to 11.2 ºC (36.5 to 52.0 ºF), whereas maternity caves are warmer, ranging from about 13 to 18 ºC (55 to 65 ºF) (Clark 1991). Relative humidity and land surface habitat variables near caves (e.g., land-use type, habitat type, elevation, distance to nearest building and pond) do not appear to be significant in determining cave selection by Ozark big-eared bats (Clark et al. 1996).

Preferred foraging habitats of the eastern subspecies include edge (Clark, Leslie, and Carter 1993), old fields, cliffs (Burford and Lacki 1995), and forest habitat (Adam, Lacki, and Barnes 1994). Primary foraging areas for the Kentucky population of Virginia big-eared bats consist of forest habitat adjacent to cliffs in the Daniel Boone National Forest (DBNF). Radiotelemetry indicated that the size of foraging areas was similar for males and females, but female foraging areas expanded in August when the young became volant. The maximum distance that any bat was observed from the roost was 8.4 km (5.2 miles). Foraging areas were found to be about 87 ha (215 acres) for males and 122 ha (300 acres) for females. Feeding roosts also occur in rock shelters in the sandstone cliffs of DBNF and typically have large openings and deep passages (Lacki, Adam, and Shoemaker 1993). Rock shelters used as maternity roosts have smaller openings but a deeper average depth (11.0 m, 36.0 ft) than those used as feeding roosts (5.8 m, 19.0 ft) (Lacki, Adam, and Shoemaker 1994).

Ozark big-eared bats in Oklahoma preferred edge habitat along intermittent streams and mountain slopes (Clark, Leslie, and Carter 1993). By foraging along woodland edges, these bats benefited from nearby cover, high prey densities, and a less-cluttered environment (Clark 1991). Females used from one to four foraging sites; median distances from maternity roosts to foraging sites increased from 1.0 km (0.6 mile) during early lactation to 4.2 km (2.6 miles) during late lactation (Clark, Leslie, and Carter 1993). Wethington et al. (1996) found no differences between males and females in number of foraging sites per bat, median size of foraging areas, or median distances to foraging areas. Females traveled shorter distances to foraging sites and used smaller foraging areas than females previously studied during the maternity season in Oklahoma.

BEHAVIOR: Townsend's big-eared bats are basically sedentary and do not migrate long distances between hibernacula and maternity caves (WWF 1990a, 1990b). These bats have a high degree of roost site fidelity, returning to the same roosts year after year; however, bats move between caves within an area, especially in winter (Clark, Clark, and Leslie 1997). The longest recorded movement for the Virginia big-eared bat is 64.4 km (40 miles) (Barbour and Davis 1969). Records for the Ozark big-eared bat are 8 km (5 miles) in Arkansas (Harvey 1992) and 7.3 km (4.5 miles) in Oklahoma (Clark, Leslie, and Carter 1993).

Townsend's big-eared bats begin to arrive at hibernacula in October and reach maximum numbers in January (Pierson et al. 1999). Individuals hibernate singly or in clusters of a few to more than 100 bats (Harvey, Altenbach, and Best 1999). Solitary bats hang upside down by one or both feet and wrap the interlocked wings around the body. Bats in clusters fold the wings against the body and coil the ears tightly against extreme cold. Although these bats usually roost in a well-ventilated area near the cave entrance, they often move to deeper warmer areas to combat extreme temperatures (Kunz and Martin 1982).

Females are colonial in summer, roosting and rearing young in maternity caves, while males roost singly or in separate smaller groups (USFWS, 8 Dec 2000). The formation of maternity colonies varies according to geographic location of the subspecies. Colonies in Virginia and Oklahoma are established from mid- to late March (Dalton, Brack, and McTeer 1986; Clark 1991), whereas Kentucky colonies form from early May through mid-June (Lacki, Adam, and Shoemaker 1994). Males may remain solitary in the southern Great Plains (Humphrey and Kunz 1976) but usually concentrate at large bachelor roosts in the eastern United States (Lacki, Adam, and Shoemaker 1994). Several maternity colonies in Kentucky were located within 2.2 km (1.4 miles) of a bachelor roost.

REPRODUCTION: Females mate in their first year, but males do not breed until their second year (Kunz and Martin 1982). Although the Virginia big-eared bat may breed as early as mid-August in Kentucky (Lacki, Adam, and Shoemaker 1994), breeding of both subspecies usually begins in autumn and continues through winter (WWF 1990a, 1990b). Fertilization is delayed until spring, shortly after arousal from hibernation, and is followed by a gestation period of 56 to 100 days. At the maternity roost, the female gives birth to one or two hairless young, which weigh nearly 25 percent as much as their mother (Harvey, Altenbach, and Best 1999). The young are generally born in May or June; juveniles are volant at 3 weeks of age and are weaned by 6 weeks.

FOOD HABITS: Townsend's big-eared bat is insectivorous and locates prey by echolocation (Harvey, Altenbach, and Best 1999). It captures flying insects in its mouth or scoops them into the tail or wing membranes and drinks by skimming close to the surface of water. Reaching down to take the insects in its mouth results in the erratic flight pattern commonly observed in late evening. Food habit studies of the western subspecies showed that they feed almost exclusively on moths (Ross 1967; Whitaker, Maser, and Keller 1977; Whitaker, Maser, and Cross 1981). Both the Virginia and Ozark big-eared bats feed primarily on small moths but also eat other insects such as flies and beetles (Clark 1991). A food habits study in West Virginia found that the volume and frequency of moths, beetles, and flies in the diet of the Virginia big-eared bat was associated with the abundance of those insects in the forest interior (Sample and Whitmore 1993). In mixed mesophytic forests of eastern Kentucky, the greatest diversity of moth species was found in stands of mature timber at the base of cliffs, and the lowest diversity of species was found in clearings (Burford, Lacki, and Covell 1999).

Townsend's big-eared bats are nocturnal and do not leave roosts until well after dark (Kunz and Martin 1982). Virginia big-eared bats have been observed foraging as far as 10.5 km (6.5 miles) from cave roosts in West Virginia, and individuals often return to the same foraging area throughout summer (West Virginia Department of Natural Resources, 8 Dec 2000). During the night, bats alternate feeding with periods of inactivity when they digest their food, often roosting near foraging areas. They may night-roost in old sheds or trees or under bridges. During early lactation, females make several nightly foraging trips from the maternity cave, but the number of trips decreases as the young mature (Clark, Leslie, and Carter 1993). By midsummer, females make only one nightly foraging trip, leaving the cave after sunset and returning at sunrise.

IMPACTS: Major impacts to Townsend's big-eared bats result from human disturbance and vandalism to caves and roost sites (USFWS 1984). Disturbance at hibernacula causes an increased demand on fat reserves that can result in direct or indirect mortality. Because bats store only enough calories to survive the winter, they burn critical reserves when aroused from hibernation (WWF 1990a). Disturbed bats often starve or leave hibernation prematurely in search of food and may abandon cave sites that are disturbed too frequently. Disturbance at maternity sites can result in direct mortality of the young or movement of maternity colonies from optimum to marginal summer roosts. When cave exploration became popular in the 1950s, some caves were disturbed so often that resident bat colonies disappeared (WWF 1990b). Formerly isolated areas in the vicinity of caves are now used for recreation and bring humans into closer and more frequent contact with bats, thus increasing the potential for disturbance and roost abandonment. Because this species exhibits strong roost fidelity, small populations such as the Ozark population are severely impacted by the loss of a single hibernaculum or maternity cave following human disturbance or natural disaster (e.g., cave collapse) (Clark et al. 1996). Closure of abandoned mines may result in severe impacts, especially to western populations, as several thousand bats may occupy a single abandoned mine (Pierson et al. 1999). Although a limited number of mines are significant bat roosts, the cumulative effects of closing many small mines and a few large ones can decimate a population.

MANAGEMENT: Major management efforts should be directed toward protecting existing and potential habitat from disturbance or loss associated with vandalism, recreational use, and commercial ventures. For example, the U.S. Fish and Wildlife Service established the Sequoyah/Oklahoma Bat Cave National Wildlife Refuge to protect habitat for the Ozark big-eared bat (USFWS, 8 Dec 2000). Known summer and winter caves used by Virginia big-eared bats have been gated or fenced to prevent unauthorized human entry in North Carolina, Virginia, and West Virginia. Gates must be properly constructed to prevent negative impacts, which sometimes occurred in the initial use of gating (Tuttle 1981). Improperly constructed gates can restrict bat movement (WWF 1990b), cause cave abandonment or dropping of young (Tuttle 1981, White and Seginak 1987), and change airflow patterns, thus altering microclimates and making cave habitat unsuitable for Townsend's big-eared bats (USFWS 1984). Gates have been redesigned to eliminate or lessen these impacts and may be the only means of protecting caves at some sites (WWF 1990a, 1990b). Angle iron has replaced round steel bars, and gate dimensions have been altered to provide more flight space (Tuttle and Taylor 1998). Bat Conservation International recommends the American Cave Conservation Association gate designs, which accommodate most cave-dwelling species. These designs are illustrated in Tuttle and Taylor (1998), which also provides construction specifications for typical bat gates used at vertical entrances and over mine shafts. Warning signs should also be posted at bat caves to provide information on the life history of bats and describe the consequences of disturbance; these signs should contain the appropriate wording to engage cooperation from potential cave users (Brady et al. 1982).

Land acquisition and management may be necessary to protect surface habitat for both eastern subspecies (USFWS 1995a). Cooperative agreements with private landowners would provide immediate knowledge of land-use changes and potential threats to critical habitats. Wethington et al. (1996) recommended that management for Ozark big-eared bats focus on areas within a radius of 8 km (5 miles) from all used caves, since this distance encompasses the known extent of their daily travel. The habitat immediately surrounding maternity caves should be protected as foraging area for newly volant young (Adam, Lacki, and Barnes 1994). Adam, Lacki, and Barnes (1994) suggested that essential habitats for the Virginia big-eared bat be determined separately for each population because of their disjunct nature. For example, cliffs and forests are essential components of foraging habitat for Virginia big-eared bats in the Daniel Boone National Forest of Kentucky. However, in other localities, they are known to forage primarily in clearings (Dalton, Brack, and Williams 1989). Surveys should be done periodically to monitor recovering populations. Since big-eared bats move among hibernacula, several winter surveys may be needed to obtain an accurate winter count in a given locality (Clark, Clark, and Leslie 1997). To determine presence of big-eared bats at a potential roost, summer surveys can be conducted using a combination of mist nets and ultrasonic detectors (e.g., Anabat II) (Kuenzi and Morrison 1998, O'Farrell and Gannon 1999). Acoustic sampling is capable of detecting bats that routinely fly outside the reach of nets and traps, but both techniques should be used to achieve the greatest effectiveness. Additional guidance on conservation and management strategies for the western subspecies of Townsend's big-eared bat is provided in Pierson et al. (1999).

POINTS OF CONTACT: For additional information, contact Dr. Wilma A. Mitchell (601-634-2929, *wilma.a.mitchell@erdc.usace.army.mil*), Mr. Chester O. Martin (601-634-3958, *chester.o.martin@erdc.usace.army.mil*), or the manager of the Ecosystem Management and Restoration Research Program, Mr. Glenn G. Rhett (601-634-3717, *Glenn.G.Rhett@erdc.usace.army.mil*). This technical note should be cited as follows:

> Mitchell, W. A. (2002). "Cave- and crevice-dwelling bats on USACE projects: Townsend's big-eared bat (*Corynorhinus townsendii*)," *EMRRP Technical Notes Collection* (ERDC TN-EMRRP-SI-27), U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/emrrp/tnotes.html*

ACKNOWLEDGMENTS: The author thanks Mr. Chester O. Martin and Dr. Richard F. Lance, Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center, for reviewing the manuscript and Ms. Monica S. Wolters, EL, for assisting with manuscript preparation.

REFERENCES

Adam, M. D., and Hayes, J. P. (2000). "Use of bridges as night roosts by bats in the Oregon Coast Range," *Journal of Mammalogy* 81(2), 402-407.

Adam, M. D., Lacki, M. J., and Barnes, T. G. (1994). "Foraging areas and habitat use of the Virginia big-eared bat in Daniel Boone National Forest, Kentucky," *Journal of Wildlife Managemen*t 58,462-469.

Arkansas Game and Fish Commission. "Threatened and endangered species: Ozark big-eared bat." *http://www.agfc.state.ar.us/threatened/bat-ozark_big-eared.html* (12 Dec 2000).

Barbour, R. W., and Davis, W. H. (1969). *Bats of America*. University Press of Kentucky, Lexington.

Brady, J. T., Kunz, T. H., Tuttle, M. D., and Wilson, D. E. (1982). "Gray bat recovery plan," U.S. Fish and Wildlife Service, Denver, CO.

Burford, L. S., and Lacki, M. J. (1995). "Habitat use by *Corynorhinus townsendii virginianus* in the Daniel Boone National Forest," *American Midland Naturalist* 134, 340-345.

Burford, L. S., Lacki, M. J., and Covell, C. V., Jr. (1999). "Occurrence of moths among habitats in a mixed mesophytic forest: Implications for management of forest bats," *Forest Science* 45(3), 323-332.

Clark, B. K., Clark, B. S., and Leslie, D. M., Jr. (1997). "Seasonal variation in use of caves by the endangered Ozark big-eared bat (*Corynorhinus townsendii ingens*) in Oklahoma," *American Midland Naturalist* 137, 388-392.

Clark, B. K., Clark, B. S., Leslie, D. M., Jr., and Gregory, M. S. (1996). "Characteristics of caves used by the endangered Ozark big-eared bat," *Wildlife Society Bulletin* 24, 8-14.

Clark, B. S. (1991). "Activity patterns, habitat use, and prey selection by the Ozark big-eared bat (*Plecotus townsendii ingens*)," Ph.D. dissertation, Oklahoma State University, Stillwater.

Clark, B. S., Leslie, D. M., Jr., and Carter, T. S. (1993). "Foraging activity of adult female Ozark big-eared bats (*Plecotus townsendii ingens*) in summer," *Journal of Mammalogy* 74, 422-427.

Dalton, V. M., Brack, V., Jr., and McTeer, P. M. (1986). "Food habits of the big-eared bat, *Plecotus townsendii virginianus*, in Virginia," *Virginia Journal of Science* 37, 248-254.

Dalton, V. M., Brack, V. W., Jr., and Williams, C. (1989). "Foraging ecology of the Virginia big-eared bat: Performance report," Virginia Division of Game, Richmond.

Dickerson, D., Martin, C. O., and Allen, H. H. (1999). "Effects of reservoir operations on individual species and communities," U.S. Army Engineer Research and Development Center EMRRP Information Exchange Bulletin 2(2), 1-4.

Genter, D. L. (1986). "Wintering bats of the upper Snake River plain: Occurrence in lava-tube caves," *Great Basin Naturalist* 46, 241-244.

Hall, E. R., ed. (1981). *The Mammals of North America*. 2nd ed., John Wiley & Sons, New York, 234-236.

Harvey, M. J. (1992). "Bats of the eastern United States," Arkansas Game and Fish Commission, Little Rock.

Harvey, M. J., Altenbach, J. S., and Best, T. L. (1999). "Bats of the United States," Arkansas Game and Fish Commission, Little Rock.

Humphrey, S. R., and Kunz, T. H. (1976). "Ecology of a Pleistocene relict, the western big-eared bat (*Plecotus townsendii*), in the southern Great Plains," *Journal of Mammalogy* 57, 470-494.

Kasul, R. L., Martin, C. O., and Allen, H. H. (2000). "Characterization of sensitive species and habitats affected by operation of USACE water resource development projects," *EMRRP Technical Notes Collection* (TN EMRRP-SI-10). U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/emrrp/tnotes.html*

Kuenzi, A. J., and Morrison, M. L. (1998). "Detection of bats by mist-nets and ultrasonic sensors," *Wildlife Society Bulletin* 26(2), 307-311.

Kunz, T. H., and Martin, R. A. (1982). "*Plecotus townsendii*," *Mammalian Species* 175, 1-6.

Lacki, M. J., Adam, M. D., and Shoemaker, L. G. (1993). "Characteristics of feeding roosts of Virginia big-eared bats in Daniel Boone National Forest," *Journal of Wildlife Management* 57, 539-543.

Lacki, M. J., Adam, M. D., and Shoemaker, L.G. (1994). "Observations on seasonal cycle, population patterns and roost selection in summer colonies of *Plecotus townsendii virginianus* in Kentucky," *American Midland Naturalist* 131, 34-42.

O'Farrell, M. J., and Gannon, W. L. (1999). "A comparison of acoustic versus capture techniques for the inventory of bats," *Journal of Mammalogy* 80(1), 24-30.

Pierson, E. D., Wackenhut, M. C., Altenbach, J. S., Bradley, P., Call, P., Genter, D. L., Harris, C. E., Keller, B. L., Lengus, B., Lewis, L., Luce, B., Navo, K. W., Perkins, J. M., Smith, S., and Welch, L. (1999). "Species conservation assessment and strategy for Townsend's big-eared bat (*Corynorhinus townsendii townsendii* and *Corynorhinus townsendii pallescens*)," Idaho Conservation Effort, Idaho Department of Fish and Game, Boise.

Pupek, D. (1997). "Big-eared bat bounces back," *Endangered Species Bulletin* 22(3), 12-13.

Ross, A. (1967). "Ecological aspects of the food habits of insectivorous bats," *Western Foundation of Vertebrate Zoology* 1, 205-264.

Sample, B. R., and Whitmore, R. C. (1993). "Food habits of the endangered Virginia big-eared bat in West Virginia," *Journal of Mammalogy* 74(2), 428-435.

Sherwin, R. E., Stricklan, D., and Rogers, D. S. (2000). "Roosting affinities of Townsend's big-eared bat (*Corynorhinus townsendii*) in northern Utah," *Journal of Mammalogy* 81(4), 939-947.

Tuttle, M. D. (1981). "Gating as a means of protecting cave dwelling bats." *Cave gating: A handbook*. R. Stitt, ed., revised 2nd ed., National Speleological Society, Huntsville, AL.

Tuttle, M. D., and Taylor, D. A. R. (1998). "Bats and mines," Resource Publication No. 3, Bat Conservation International, Austin, TX.

U.S. Fish and Wildlife Service. (USFWS). "Virginia big-eared bat (*Plecotus townsendii virginianus*) and Ozark big-eared bat (*Plecotus townsendii ingens*)." *http://endangered.fws.gov/i/a/saa7r-.html* (8 December 2000).

U.S. Fish and Wildlife Service (USFWS). (1984). "A recovery plan for the Ozark and Virginia big-eared bats," North-Central Regional Office, Twin Cities, MN.

U.S. Fish and Wildlife Service. (USFWS). (1995a). "Ozark big-eared bat (*Plecotus townsendii ingens* (Handley)) revised recovery plan," Tulsa, OK.

U.S. Fish and Wildlife Service (USFWS). (1995b). "Recovery updates, region 5: Virginia big-eared bat," *Endangered Species Bulletin* 20(4), 21.

U.S. Fish and Wildlife Service (USFWS). (1996). "Recovery updates, region 5: Virginia big-eared bat," *Endangered Species Bulletin* 21(1), 31.

U.S. Fish and Wildlife Service (USFWS). (1997). "Regional news, region 5: Virginia big-eared bat," *Endangered Species Bulletin* 22 (1), 31.

Wackenhut, M. C. (1990). "Bat species over-wintering in lava-tube caves in Lincoln, Gooding, Blaine, Bingham, and Butte Counties, Idaho," M.S. Thesis, Idaho State University, Pocatello.

West Virginia Division of Natural Resources. "West Virginia wildlife: Virginia big-eared bat (*Corynorhinus townsendii virginianus*)." *http://www.dnr.state.wv.us/wvwildlife/va%20bat.htm* (8 Dec 2000).

Wethington, T. A., Leslie, D., M., Jr., Gregory, M. S., and Wethington, M. K. (1996). "Prehibernation habitat use and foraging activity by endangered Ozark big-eared bats (*Plecotus townsendii ingens*)," *American Midland Naturalist* 135, 218-230.

Whitaker, J. O., Jr., Maser, C., and Cross, S. P. (1981). "Food habits of eastern Oregon bats, based on stomach and scat analyses," *Northwest Science* 55, 281-292.

Whitaker, J. O., Jr., Maser, C., and Keller, L. E. (1977). "Food habits of bats of Western Oregon," *Northwest Science* 51, 46-55.

White, D. H., and Seginak, J. T. (1987). "Cave gate designs for use in protecting endangered bats," *Wildlife Society Bulletin* 15, 445-449.

World Wildlife Fund (WWF). (1990a). "Ozark big-eared bat (*Plecotus townsendii ingens*)." *The official World Wildlife Fund guide to endangered species of North America*. World Wildlife Fund, ed., Beacham Publishing, Washington, DC, 527-529.

World Wildlife Fund (WWF). (1990b). "Virginia big-eared bat (*Plecotus townsendii virginianus*)." *The official World Wildlife Fund guide to endangered species of North America*. World Wildlife Fund, ed., Beacham Publishing, Washington, DC, 530-532.